

## **Estimating Consequences of MMOD Penetrations on ISS**

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The threat from micrometeoroid and orbital debris (MMOD) impacts on space vehicles is often quantified in terms of the probability of no penetration (PNP). However, for large spacecraft, especially those with multiple compartments, a penetration may have a number of possible outcomes. The extent of the damage (diameter of hole, crack length or penetration depth), the location of the damage relative to critical equipment or crew, crew response, and even the time of day of the penetration are among the many factors that can affect the outcome. For the International Space Station (ISS), a Monte-Carlo style software code called Manned Spacecraft Crew Survivability (MSCSurv) is used to predict the probability of several outcomes of an MMOD penetration—broadly classified as loss of crew (LOC), crew evacuation (Evac), loss of escape vehicle (LEV), and nominal end of mission (NEOM). By generating large numbers of MMOD impacts (typically in the billions) and tracking the consequences, MSCSurv allows for the inclusion of a large number of parameters and models as well as enabling the consideration of uncertainties in the models and parameters. MSCSurv builds upon the results from NASA's Bumper software (which provides the probability of penetration and critical input data to MSCSurv) to allow analysts to estimate the probability of LOC, Evac, LEV, and NEOM. This paper briefly describes the overall methodology used by NASA to quantify LOC, Evac, LEV, and NEOM with particular emphasis on describing in broad terms how MSCSurv works and its capabilities and most significant models.